CHAPTER 7
AGRICULTURAL SECTOR - ENERGY USES

7.1 INTRODUCTION

The agriculture sector has at its core the production process for foodstuff (e.g., grains, fruits and vegetables, meat, fish, poultry, and milk), and non-food vegetable products of economic value (e.g., tobacco, jute, hemp). However, the sector also comprises or has close links with processes that take place before and after this core production process, such as fertilizer production, post-harvest processing, and transport of foodstuff. Defined broadly, the agriculture sector has as its primary goal the delivery of food on the table for the population or for export. Thus, any measure that will reduce the energy consumption while delivering the food service is in principle a potential candidate for analysis as a mitigation option.

Despite the relative importance of this sector to economic activity and employment in the developing countries, agricultural energy use tends to be small compared to that in industry or transport. Energy is mainly used for ground water pumping and farm machinery such as threshers and tractors. In many cases, electricity and fuel use tends to be inefficient because of price subsidies, and thus mitigation options may offer a significant potential for improving efficiency and reducing GHG emissions from this sector.

7.2 MITIGATION OPTIONS

Potential mitigation options for agricultural energy use are described below. While some of the options are not yet available for widespread implementation, or need more scientific and economic analysis before their applicability can be assessed, they are also presented since they might become feasible later on.

The main near-term option likely to be of interest for GHG mitigation is efficiency improvement in irrigation. The use of various renewable sources of energy for agricultural applications (e.g., wind-driven pumps, solar drying, diesel engines powered with mostly gasified biomass) have been tested on a limited scale and may be of interest in some cases. (Agricultural residues may also be used for meeting energy demands outside the agriculture sector - e.g., for cogeneration in agro-processing industries.)

- **Reduce energy use for irrigation.** Irrigating crops often requires considerable amounts of electricity or diesel fuel. Reducing energy consumption for irrigation while providing the desired service may be accomplished through use of more efficient pump sets and water-frugal farming methods.

  To improve the efficiency of irrigation pump sets, a number of technical measures are available. These include: use foot valves that have low-flow resistance; replace undersized pipes and reduce number of elbows and other fittings that cause frictional losses; use high-efficiency pumps; select pumps better matched to the required lift characteristics; use rigid PVC pipes for suction and delivery; operate pumps at the recommended RPM; select prime mover for the pump (i.e., electric motor or diesel engine) matched to the load; select an efficient diesel engine or motor for the application; schedule and perform recommended maintenance of the pump and the prime mover; and ensure efficient transmission of mechanical power from the prime mover to the pump. For further discussion of the potential for improving pump sets, see OR Group (1993).

- **Increase the efficiency of non-pumping farm machinery.** Energy use for traction for cultivation, sowing, weeding, harvesting, and other operations can be reduced through use of more efficient equipment or by minimizing the need for traction through low-tillage agriculture.

- **Switch to lower-carbon energy sources.** Options in this category include wind- and photovoltaic-powered pumps, enhanced solar drying, and use of biofuels instead of fossil fuels in various applications where heat is required.

- **Reduce input of chemical fertilizers.** The two basic ways of reducing the input of chemical fertilizers are to target fertilizer application better and to substitute organic or microbial fertilizers for chemical fertilizers. Reduced demand for chemical fertilizer lowers energy use in the chemical industry. There have been limited studies in developing and transition countries on reducing the intensity of chemical fertilizer inputs through improved application or use of organic fertilizers so assessing the potential impact of this option is difficult.

- **Use conservation tillage systems.** Conservation tillage practices store carbon in the soil through retention of vegetative matter (crop residue). Since most conservation tillage practices reduce the number of trips across a field needed to grow and gather a crop, total energy required to grow a crop is reduced.

- **Improve efficiency of post-harvest drying and storage.** Various agricultural products are subjected to drying or cold storage before they are sent to market. The efficiency of these processes can generally be improved through use of better equipment and proper maintenance.

- **Reduce post-harvest foodgrain losses.** Assuming that food needs are being met, use of storage methods impervious to pests and rodents can reduce the need for crop production, thereby saving the energy that would be used in that production.

7.2.1 Screening of Options

Screening of options for the agriculture sector should consider their possible impacts on a number of critical issues other than cost-effectiveness and reduction in GHG emissions. Analysis of these impacts is important because some of them may be unacceptable despite attractive GHG reduction potential for the option. Some of the most significant issues for screening (and evaluating) mitigation options are:

- Impact on the local environment
- Impact on unemployment and on enterprise development
- Impact on income distribution and social equity
- Impact on national security - dependence on imports for food, fuel
- Impact on capital investment
- Impact on foreign exchange reserves (i.e., balance of payment).

Each country may have specific additional issues that require consideration in the screening of mitigation options. Some of these issues have quantitative criteria for acceptability (e.g., the rate of return on social investment must meet the norm set for other social investments). Others may have only qualitative criteria.

7.3 INPUTS FOR AGRICULTURE SECTOR ANALYSIS

The initial inputs for agricultural scenarios are base-year data on agricultural production and fuel and electricity use. A projection of future value added or the future production of food grain can be based on government plans or expert estimates. The analyst may divide the agricultural sector into two components: irrigated agriculture, where data and information on particular mitigation options for pumping and on-farm machinery may be available, and non-irrigated area, whose commercial energy use and intensity is usually very low.

Analysis of selected equipment requires disaggregation of energy consumption by end use. Major end uses include irrigation, field operations, post-harvest processing, and livestock facilities. Detailed end-use data are often sparse for the agriculture sector. As a rough approximation, one can usually assume that nearly all of the electricity consumption is for irrigation. Fuel use is divided primarily between diesel pumps and field operations.

End uses being analyzed should be characterized in terms of the number and average energy intensity of existing equipment. Projection of the future stock of each type of equipment may be based on future production. For projecting the stock of pumping equipment, estimates of the future amount of irrigated crop area and future crop patterns are also useful inputs.

An analysis of new equipment requires similar data as in other energy-demand sectors. For example, data on performance and cost of standard and energy-efficient pump sets may be gathered from equipment manufacturers, and the cost and energy savings may be calculated for one or more typical applications. One may use one size/type of equipment or several.

For retrofit improvements to existing equipment, the average energy savings and cost for typical applications may be based on actual measurements from projects or on engineering calculations.

7.4 DEVELOPING SCENARIOS

7.4.1. An End-Use Accounting Framework

The basic steps in an end-use analysis of agricultural equipment are listed in Table 7-1. This analysis requires an estimate of base-year electricity or fuel consumption for the end use and considers evolution of equipment stocks. For irrigation, for example, one begins with base-year data on the number and average energy intensity of pump sets by type (fuel/electric) and size and then projects growth in the total number of pumps of each type/size. One retires existing pumps at a specified rate and these are replaced by new pumps. Mitigation options that may be considered include use of high-efficiency rather than standard pumps and retrofit of existing pumping systems.

Where agricultural energy consumption is a significant component of total energy use, a study team may wish to use a more detailed approach which analyzes the evolution and energy intensity of irrigation pumps and other equipment for each crop type (see Moulik *et al*. 1990). This approach requires sufficient data and information on irrigation pumps and other equipment to be able to project their numbers and future energy intensity with some confidence.

The cost-effectiveness of technology options can be based on how the CCE compares to the cost of electricity or fuel. If a measure meets the test of economic acceptability from the societal perspective, one should assess its impact on other important issues (such as unemployment and enterprise development, local environment, food security, foreign exchange reserves).

Table 7-1. Basic End-Use Analysis for Agriculture Energy
(Electric or Diesel Irrigation Pumps Example)

- Obtain data on base-year number and average energy intensity of pumps by size.
- Estimate future number of pumps in each size class.
  Use growth rate based on projected growth in VA or irrigated area.
- Estimate retirement rate for base-year pumps.
- Obtain data on average energy intensity and cost of new standard and high-efficiency pumps.
- Estimate potential average energy savings and cost associated with retrofit of surviving base-year pumps.
- Calculate *baseline* energy consumption for each class of pumps.
  Frozen efficiency: no retrofits, standard new pumps
  Likely trends: some retrofits, mix of standard and high-efficiency new pumps
- Calculate *technical potential* energy consumption.
  ~100% retrofits, ~100% high-efficiency new pumps*
- Estimate portion of technical potential that is cost-effective.
- Identify and evaluate mitigation policies and estimate achievable potential.

* In practice, the measures will not be applicable for all cases; some adjustment must be made.

7.4.2 Scenario Development Without End-Use Analysis

If data are lacking to conduct end-use analysis, a simple approach may be used to construct scenarios for agricultural energy use. The steps in an aggregate analysis are listed in Table 7-2. This analysis uses a measure of total agricultural production such as the total tonnes of food grain or total value added. The main task is to project the future aggregate fuel and electricity intensity (i.e., energy use per tonne of grain or unit of value added) for baseline and mitigation scenarios. The technical potential for GHG mitigation is roughly assessed without evaluation of specific options.

Table 7-2. Aggregate Analysis for Agriculture Energy Use

- Obtain base-year grain production or value added by agriculture.
- Obtain or estimate base-year energy use for agriculture by fuel type.
- Project future grain production or value added by agriculture using likely trends or government plans.
- Calculate the base-year intensity of fuel and electricity use.
- Project future baseline intensity of fuel and electricity use.
- Project future intensity of fuel and electricity use in mitigation scenario.
- Calculate future fuel and electricity use.
- Estimate mitigation scenario fuel and electricity use.
- Estimate fuel and electricity savings in mitigation scenario.
- Identify mitigation policies.

The construction of baseline and mitigation energy scenarios at the aggregate level is relatively straightforward. The baseline projection of energy intensities should consider past trends and also what areas of land will be under cultivation for various crops, using what degree of irrigation, machinery, and fertilizers. The projection of aggregate fuel and electricity intensity in the mitigation scenario should be done by roughly estimating the technical potential for reducing intensities. For example, one might judge that a variety of options could reduce aggregate electricity intensity by 15% in the target year. In this approach, estimating the cost of mitigation is very difficult.

7.5 MITIGATION POLICIES

The available policy options for the agriculture sector are generally similar to those for industry. They include efficiency standards for generic equipment, energy audits, loan programs, and financial incentives. In both sectors, opportunities for efficient use of resources and use of non-fossil energy resources tend to be rather site-specific so policy responses require some kind of outreach. Agriculture presents a particular challenge, however, because of the large number of individual enterprises spread over a wide area. Thus, greater management resources are needed to implement and monitor policies. In addition, in many countries, subsidies to energy and other agricultural inputs limit interest in their more efficient use. Reduction or removal of such subsidies will encourage both more efficient use and application of renewable technologies.

Design of policies needs to account for the impacts on different stake-holders, especially those who may stand to lose from a policy and will thus need to be rewarded (Bhatia and Pereira, 1988). For example, reduced electricity sales from more efficient electric pump sets might be attractive to a utility because of reduced outlays for subsidy of agricultural electricity. On the other hand, the farmer may have higher payments of principal and interest. Similarly, there will be economic impacts on technology suppliers, consumers, traders, and so on. If the measure is societally attractive but not attractive from the perspective of some of the stake-holders, it need not be rejected. Policy means, such as easy credit, may be used to compensate the losers while the society as a whole still gains from the implementation of options.

REFERENCES

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